FIELD CAMPAIGNS AND AIR QUALITY MONITORING – PART 2

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WASCAL Course 608 – Part 2 – 19 June 17

TALK OUTLINES

- Science & Species: Air Quality Basics – Part 1 (15/6/17)
  - Key Species
  - Scientific Issues that motivate campaigns
- Monitoring from Space - Part 1
  - NO_2 – Decadal changes, environmental "success tale"
  - Ozone – Challenge and Status in tropical troposphere
  - HCHO- see Prof Marais' Talk
- **AQ Data & Field Campaigns – TODAY'S TALK**
  - **More about SHADOZ network, Quality Assurance, Satellite data evaluation with TTOR**
  - **Why & How Campaigns. Data analysis. Example: KORUS-AQ, May-June 2016**
  - **Follow-up - Hands-on, Work with data**

RECALL LAST LECTURE ON TROPOSPHERIC O_3 SATELLITE PRODUCTS AND SONDE DATA

- Monthly maps of column O_3 amounts useful in tropics for studying interannual variability but different products diverge widely (TOAR Assessment to evaluate. Stay tuned)
- Ozonesondes in tropics are limited to SHADOZ (http://tropo.gsfc.nasa.gov/shadoz). Vital for satellite validation. 19-yr data record is available for study of climatology and interannual variability.
- Present more on SHADOZ and Quality Checks. Based on al. (*JGR*, 2012) & Thompson et al. (in preparation, 2017)
- **Assignment for YOU. Work with SHADOZ data from equatorial African stations, AERONET, meteo. observations, eg precipitation; model re-analyses**

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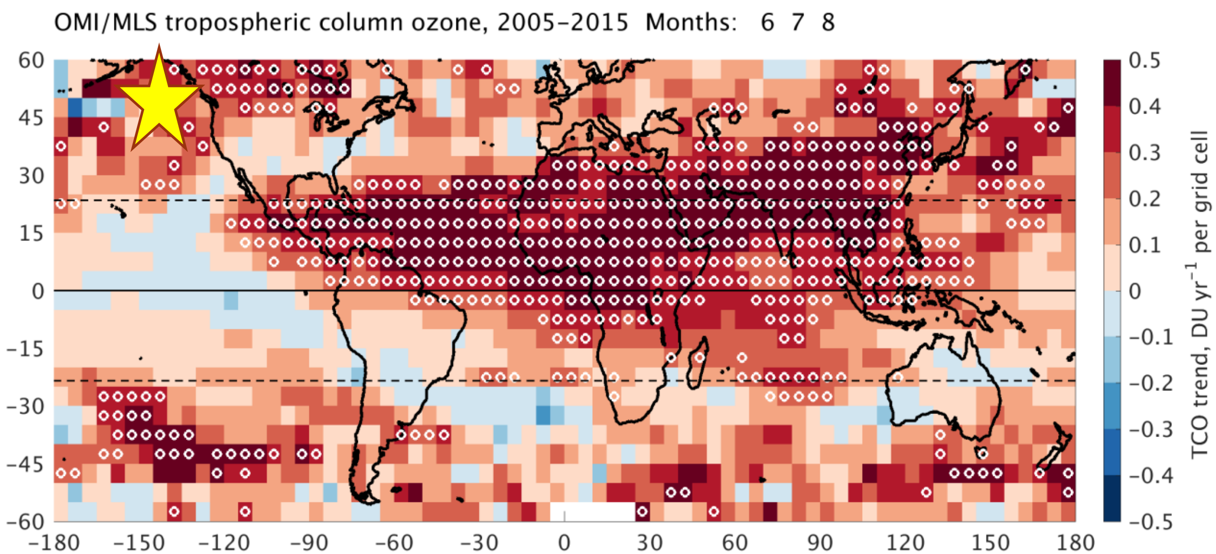
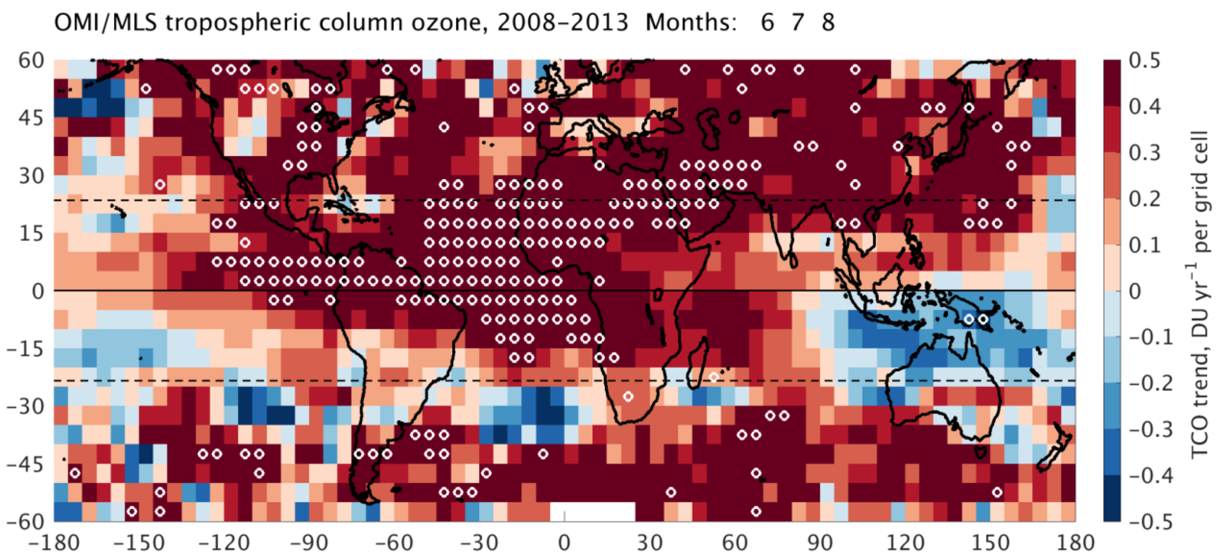
OMI-MLS TRENDS
(OWEN COOPER ET AL.). IGAC/TOAR REPORT, 2017





2005-2015 (JJA)

White dots indicate statistically significant trend

Zhang et al, *Nature-Geoscience,* 2016

CAVEAT! SONDES DISPLAY <u>NO O_3 INCREASES</u> IN CANADA

2008-2013 (JJA)

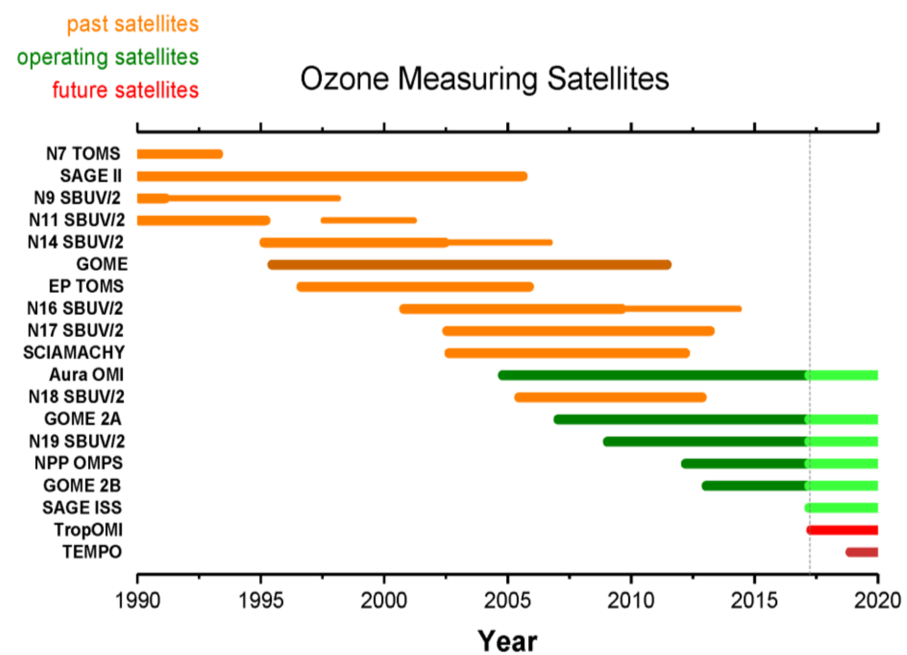
To match IASI record In Wespes et al., ACP, 2016.

WHY, WHERE, HOW: SHADOZ START IN 1998. 2017: > 7000 PROFILES

- "Strategic" ozonesonde network coordinates launches in space & time for specific scientific purposes
- Satellite Requirements: Validate O_3 profiles from TOMS/ UARS/SBUV (90s), ENVISAT, Aura, NPP, MetOp (2000->)
- Scientific Needs: Where does total ozone wave-one originate – in stratosphere or troposphere? => *Requires zonal coverage of stations*. **PRACTICAL CONSTRAINTS**
  - **Operational – host supplies ground stations, launch gas, personnel**
  - **NASA, NOAA supply *some* sondes – ALL data archived @ GSFC**
  - **Data distribution: open, timely, user-friendly format**
  - **Leveraging resources has led to sustained network success**

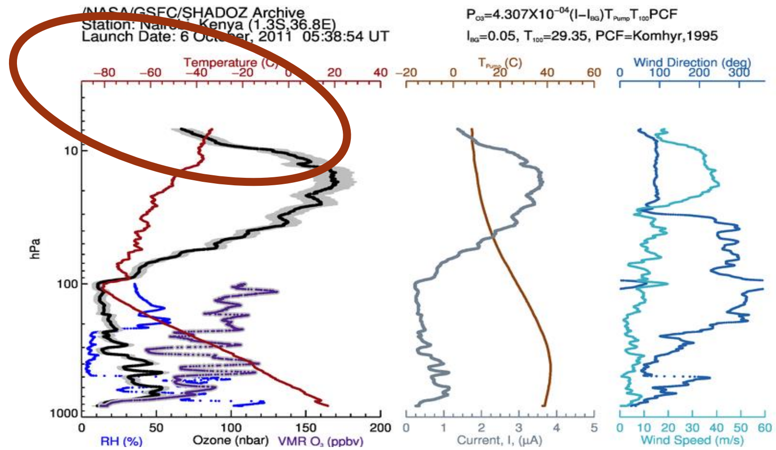
SHADOZ Sites, URL=http//:croc.gsfc.nasa.gov/shadoz

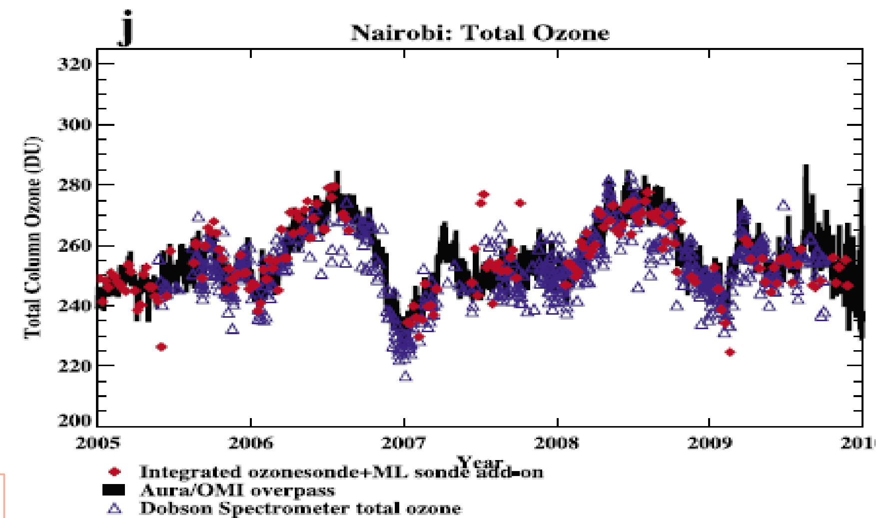
"Tropical Stations," 10 at < 19deg lat



SHADOZ QUALITY ASSURANCE: COMPARE SATELLITE OVERPASS & GROUND-BASED INSTRUMENT TOTAL OZONE COLUMNS

- Total column ozone from satellites in TOMS (1998-2004), OMI (2005-present), OMPS (2011- present) carefully calibrated with global ground-based spectrometers
- For sondes extrapolate ozone above burst to compute total O_3
- Example. Nairobi sonde (Upper)
  - Total ozone with OMI (2005-2009), five-yrs, with Dobson, agree within 1%! (Lower)
  - => Confident in using Nairobi data to evaluate tropospheric ozone TTOR product (Next)

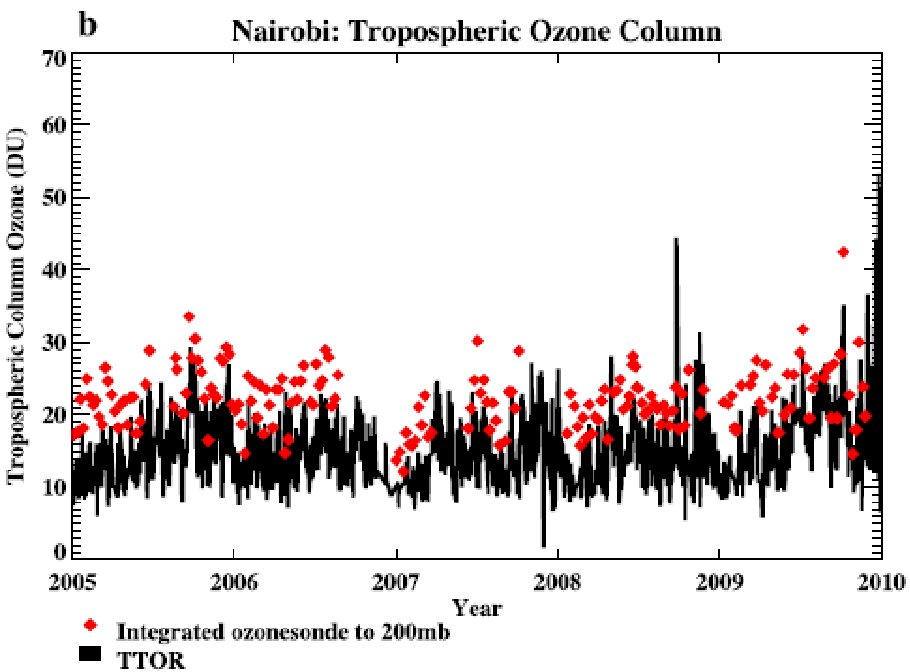


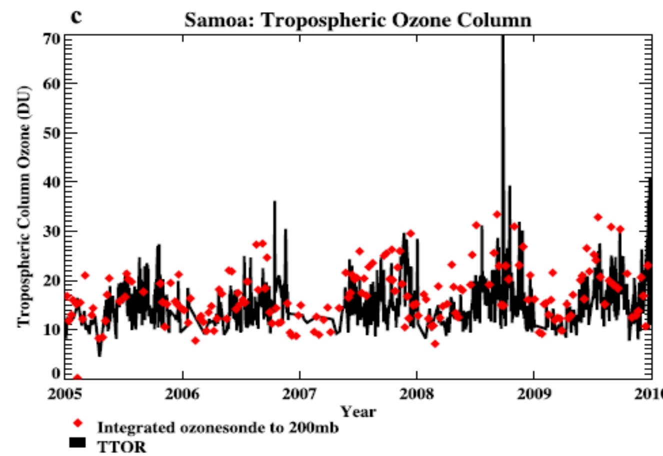


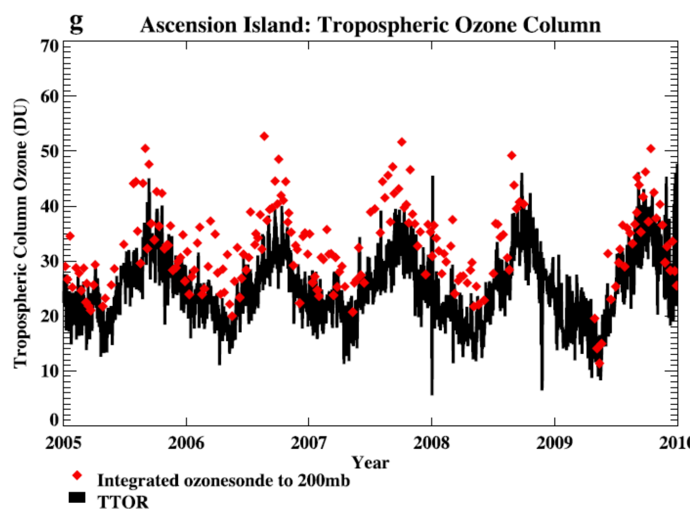
Thompson

Thompson et al, 2012

TROPOSPHERIC "TTOR" PRODUCTS – AVERAGE 20-25% LOW, DO NOT CAPTURE RANGE OF VARIABILITY







SHADOZ:
http://tropo.gsfc.nasa.gov/shadoz

Thompson et al, 2012

Thompson

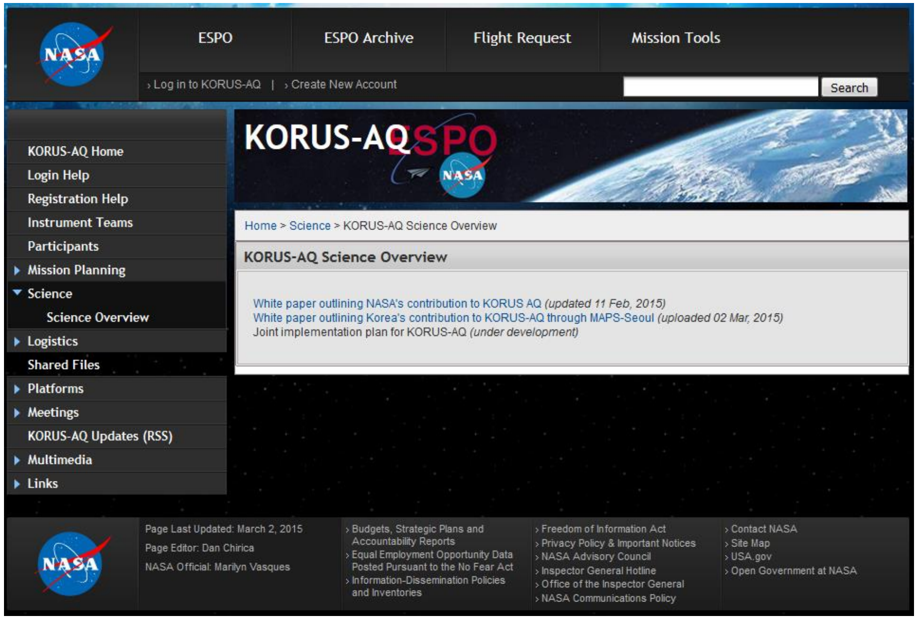
CAMPAIGNS: WHY, HOW, WHEN, WHERE THEY ARE CONDUCTED?

- Satellites give global view but tend to be too coarse in horizontally & vertically to resolve structure. Poor near-surface viewing, limited numbers of species
- **Goals of Field Campaigns:**
  - **Validate evolving satellite products**
  - **Measure many species and processes, e.g. meteorological parameters radar, winds, boundary-layer height**
  - **Analyze data & relationships to test hypotheses about processes**
  - **Further analyze with models to answer process questions quantitatively. Test theories, evaluate models, sources (refer to Marais talks)**

WHY, HOW, WHEN, WHERE OF MODEL FIELD CAMPAIGN: KORUS-AQ **

- Joint Korea-US (KORUS) campaign, May-June 2016 in ROK
- Prepare for GEMS geo-stationary Korean satellite (2019) with prototype field campaign
- Integrate aircraft, ground-based, satellite data with models
- Study existing data to prepare **WHITE PAPER** with scientific needs, justification, concept and strategies.
- White Paper is "open for comments" and multiple groups may contribute, decide to join

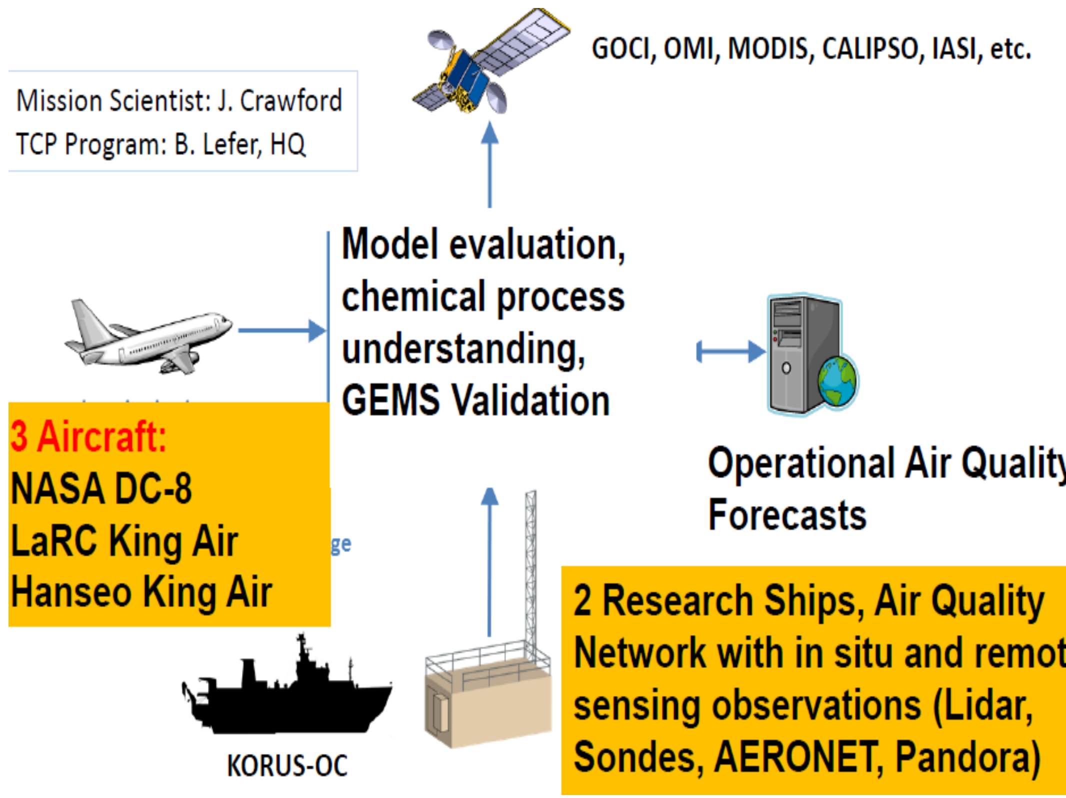
- **espo.nasa.gov**/home/**korus-**aq/content/**KORUS**-AQ



Thompson *** **THREE AFRICA CAMPAIGNS: SAFARI-92/TRACE-A.** ***JGR*****, 1996; SAFARI-2000.** ***JGR*****, 2003; SAFARI-2000; AMMA (West Africa)** ***ACP*** **papers. ORACLES – 2016-2019**

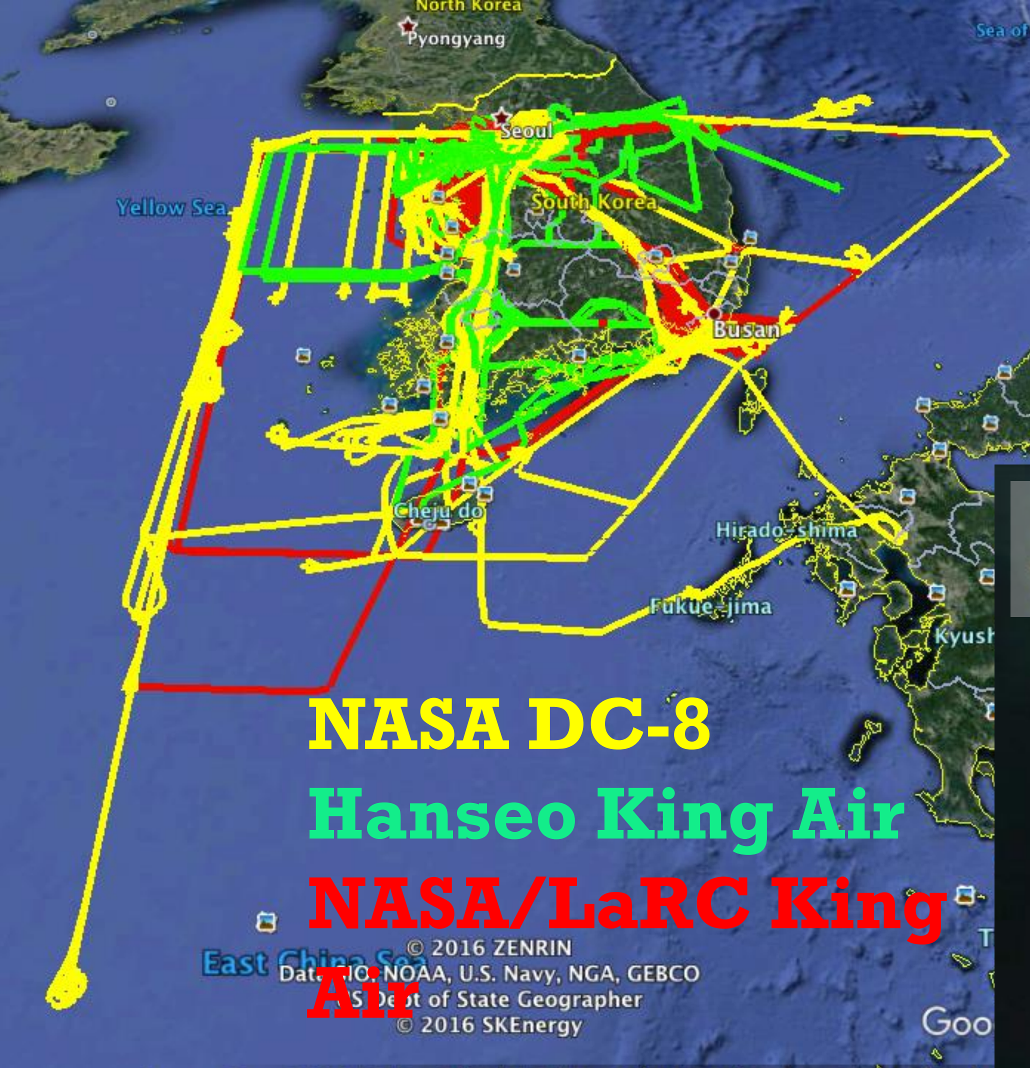
MOTIVATIONS & APPROACH FOR KORUS-AQ

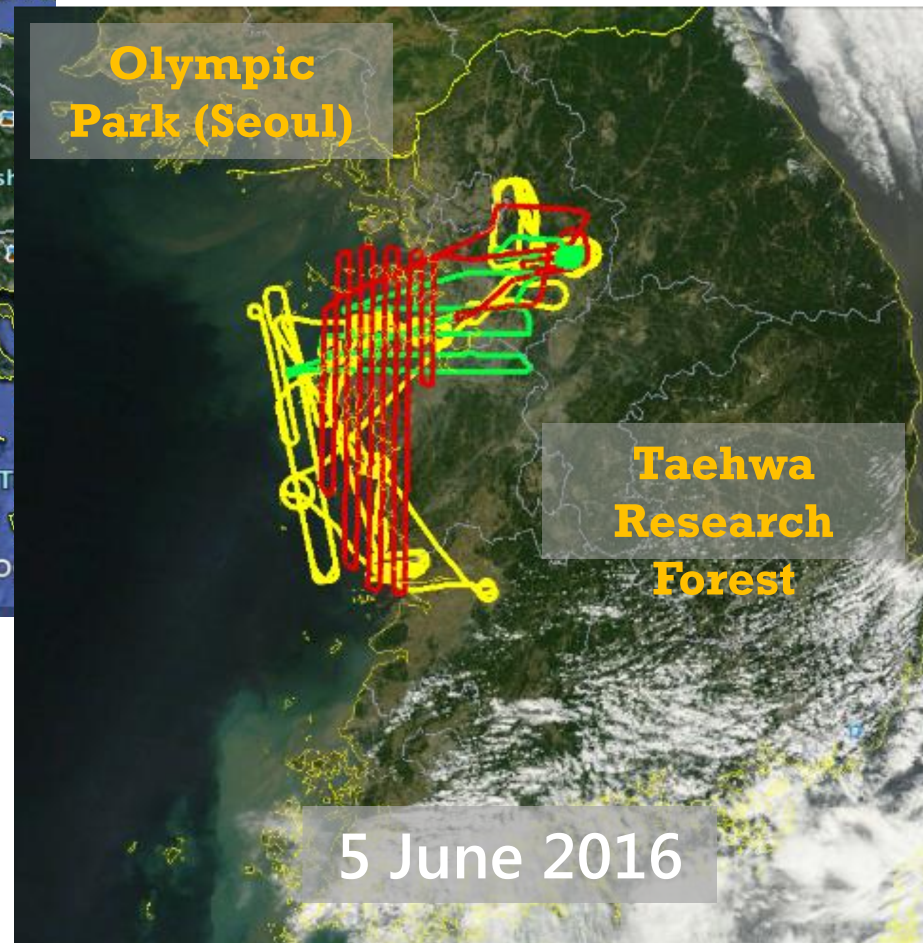
- Scientific Goals & Questions
  - Collect many vertical profiles of ozone, HCHO, NO2 for statistics on geo-stationary satellite
  - Compare ground & aircraft measurements
  - What are main ozone and PM procuesses?
  - Is Seoul area pollution predominantly <u>local or from elsewhere</u> (China)?
  - Mix Korean & US instruments, aircraft & researchers



FLIGHT TRACKS

- Entire Campaign (Left – 22 flight days)
- Ground-sites near Seoul (below)





NASA DC-8: In-situ and remote-sensing trace gas, aerosol, met. instrumentation

Hanseo Univ. King Air: In-situ trace gases

NASA King Air: Geo-TASO and MOS (ocean color, atmospheric correction)

KORUS-AQ SAMPLE FINDINGS

- Korean air very dirty!
- Koreans have many sources of VOC, Nox
- New VOC, HCHO instruments reveal evolution of pollution
- Tracers and trajectories point to both China <u>and strong Korean sources!</u>
- New NASA instruments – Pandora, Ozone Lidar – collect useful data.

Rural, Resort Area, Konjiam

Below Fast-Growing city

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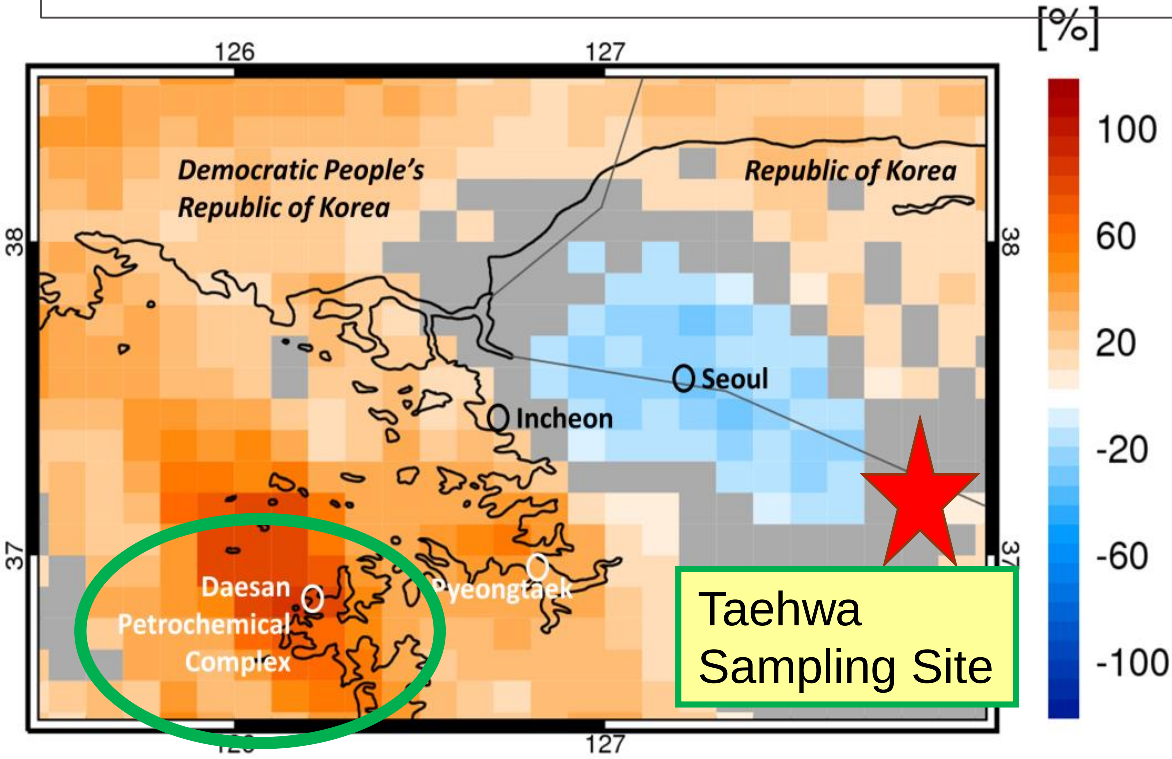
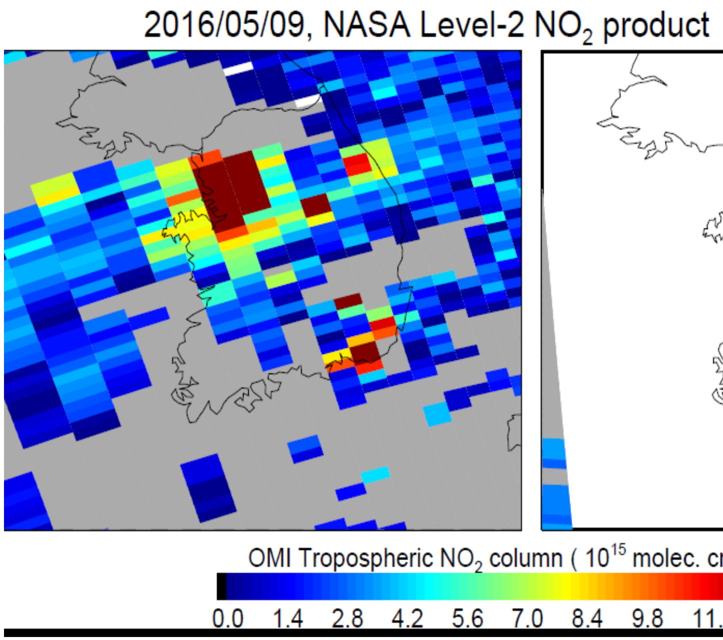
BACKGROUND CLIMATOLOGY & MAY 2016 SAMPLE OF OMI NO2

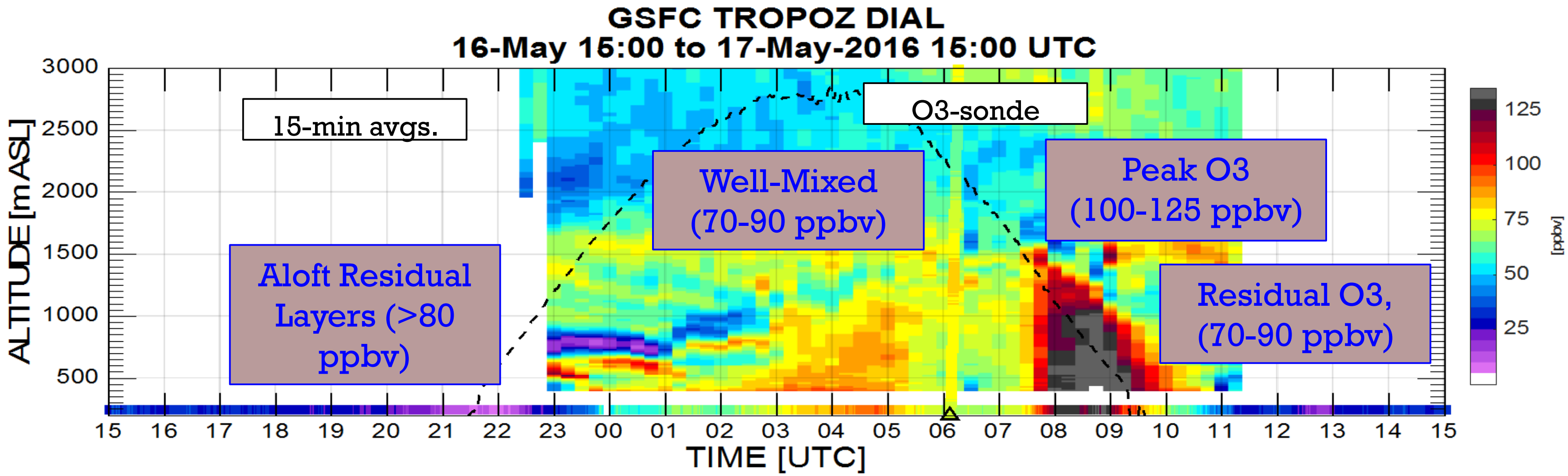




ΔOMI NO_2 (%): 2005-2014 **Seoul, Busan, 9/5/16**

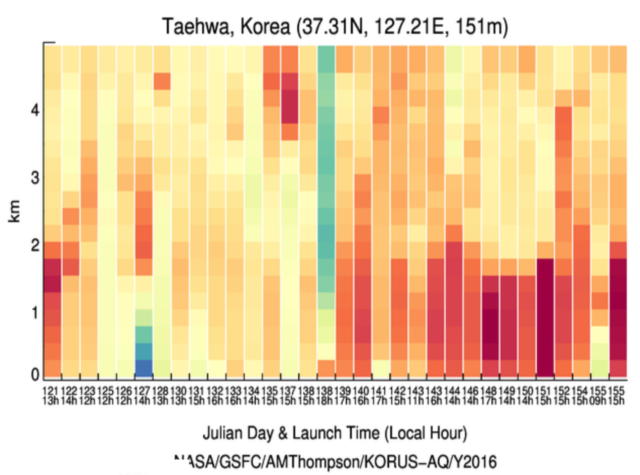
High NO_2 – Korean cities

KORUS-AQ EXPERIMENT, KOREA, MAY 2016
GSFC TEAM: TAEHWA FOREST, 30 KM E OF SEOUL



Surface O_3
75-110 ppbv

O_3 > 2x Maryland (DC) O_3 In 2011



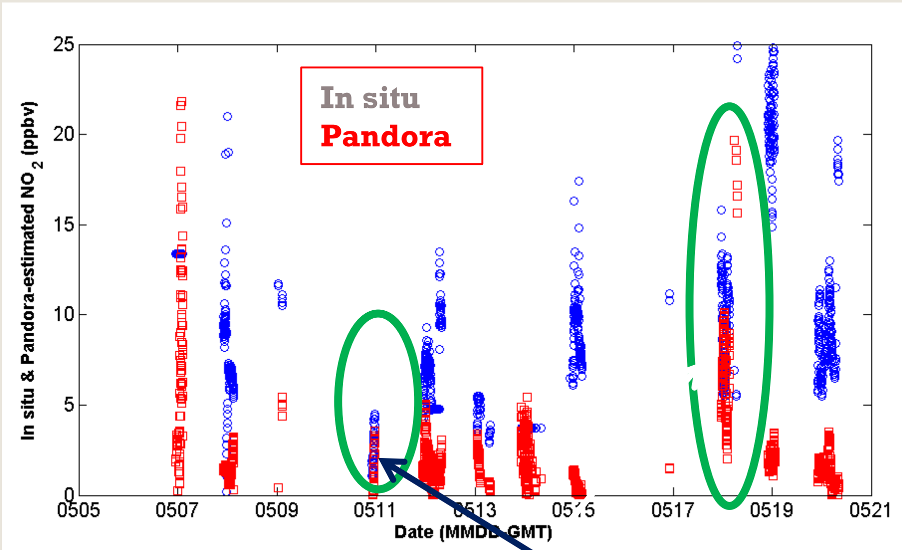
Typical Afternoon Haze, Taehwa Research Forest

MEASURING NO_2 @ TAEHWA. IN-SITU AND PANDORA SPECTROMETER

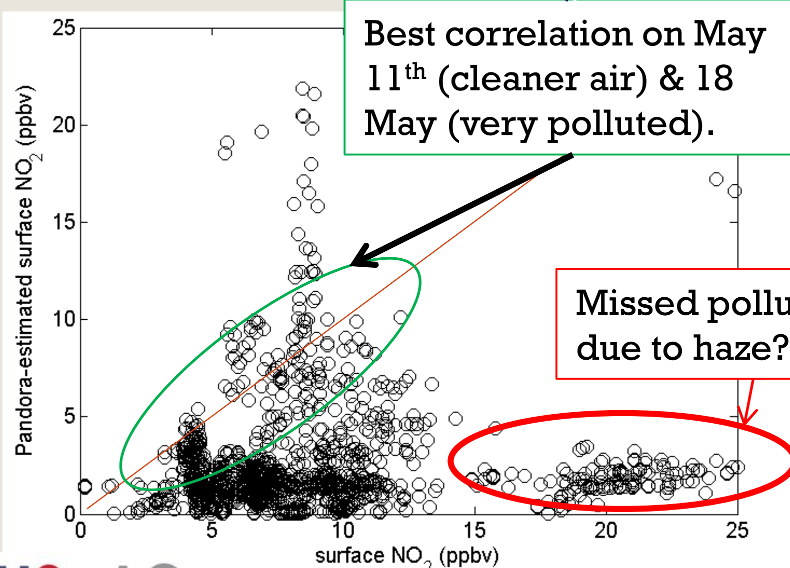
Sondes next to Trailer with
Lidar, In-situ ozone, NO_2 instruments

Pandora at Taehwa!
Nader Abuhassan, Pandora Engineer

EVALUATION OF IN SITU & PANDORA-ESTIMATED SURFACE NO_2?



Best correlation on May 11th (cleaner air) & 18 May (very polluted).



Missed pollution due to haze?

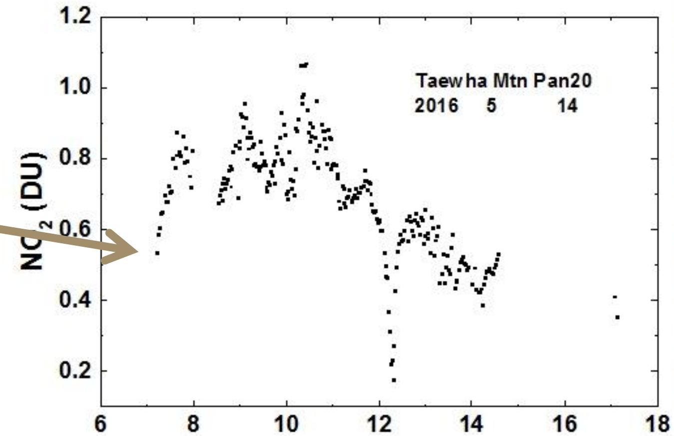
- **Why do several days after 14 May show too-low Pandora surface NO_2?**
- Best guess is the interference of aerosols and clouds, which affects the Pandora retrieval.
- Looking at one particular case on 14/15 May, the method does not work in high-aerosol conditions.

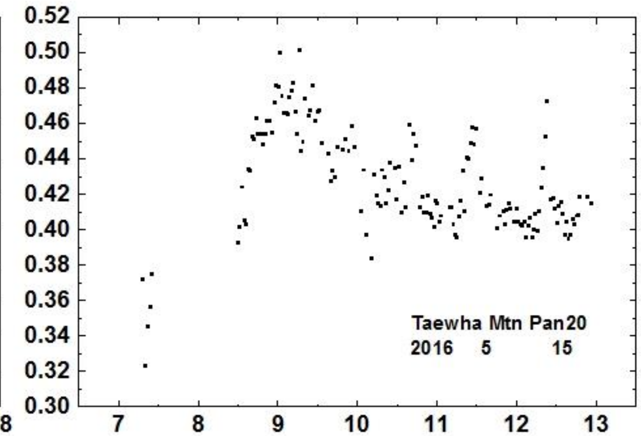
KORUS-AQ

RESULTS #3: WHY DO SOME DAYS HAVE 10+ PPBV IN- SITU & PANDORA-ESTIMATED SURFACE NO_2 DIFFERENCES

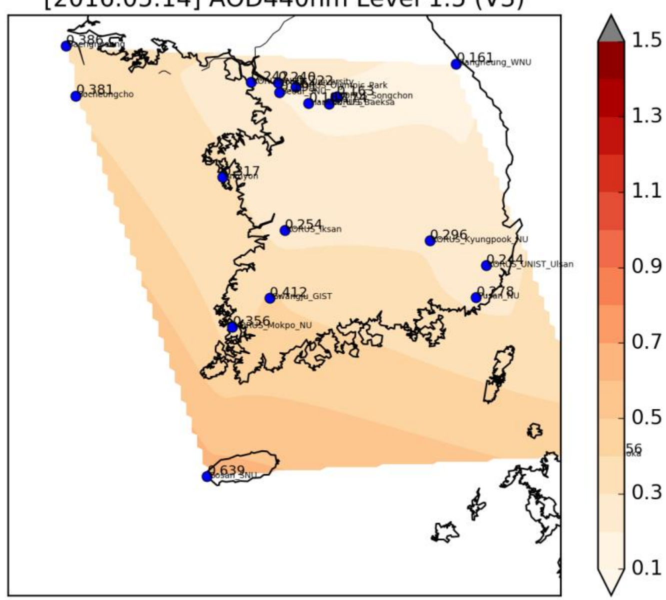
Diurnal NO_2 columns (in Local Time) courtesy of Jay Herman.

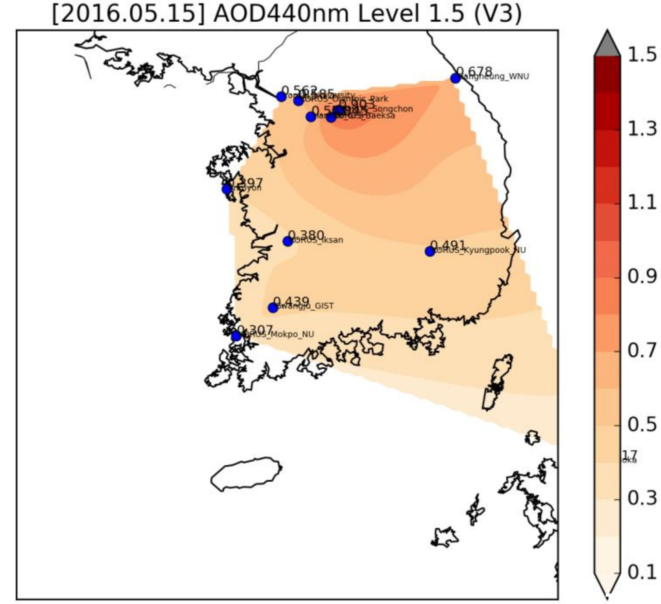
Drop in NO_2 column abundance from May 14th to 15th.





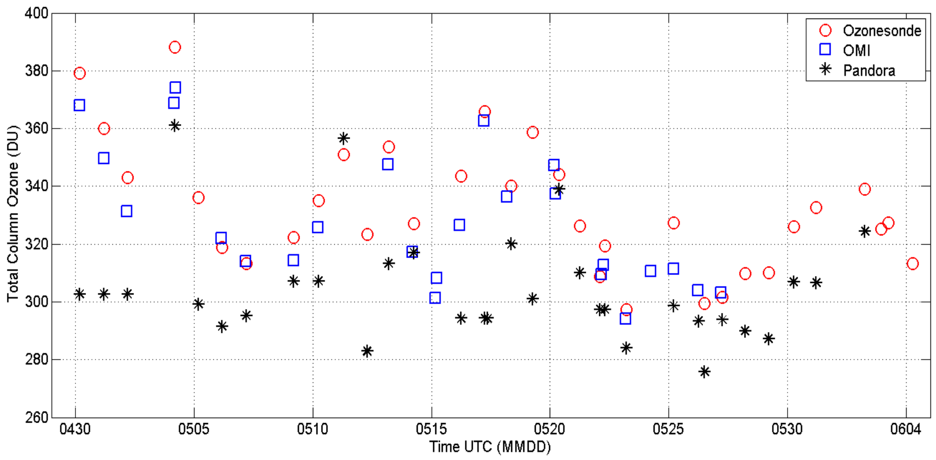
AERONET DRAGON KORUS-AQ AOD from May 14th/15th shows increase in particles over Taehwa.

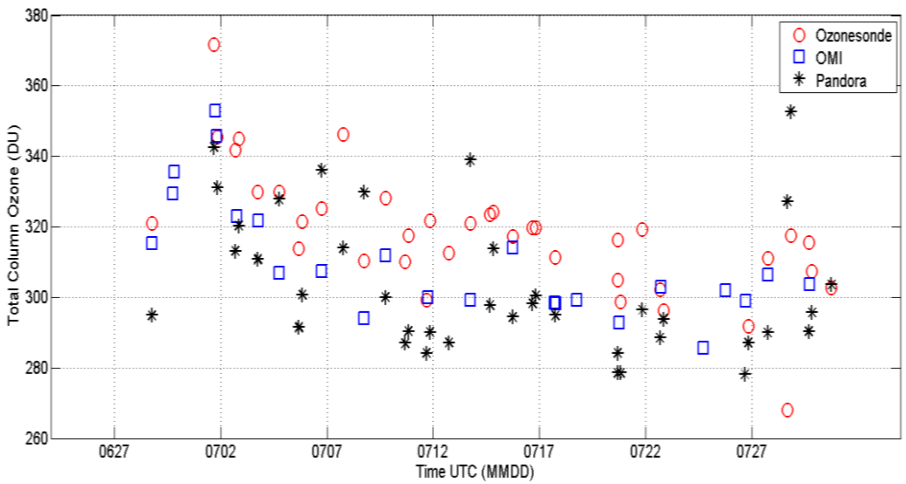




KORUS-AQ

MEASURING O_3 @ TAEHWA. IN-SITU, OMI AND PANDORA SPECTROMETER. COMPARE TO MARYLAND (2011) CAMPAIGN, WHICH IS BETTER (FEWER AEROSOLS?)





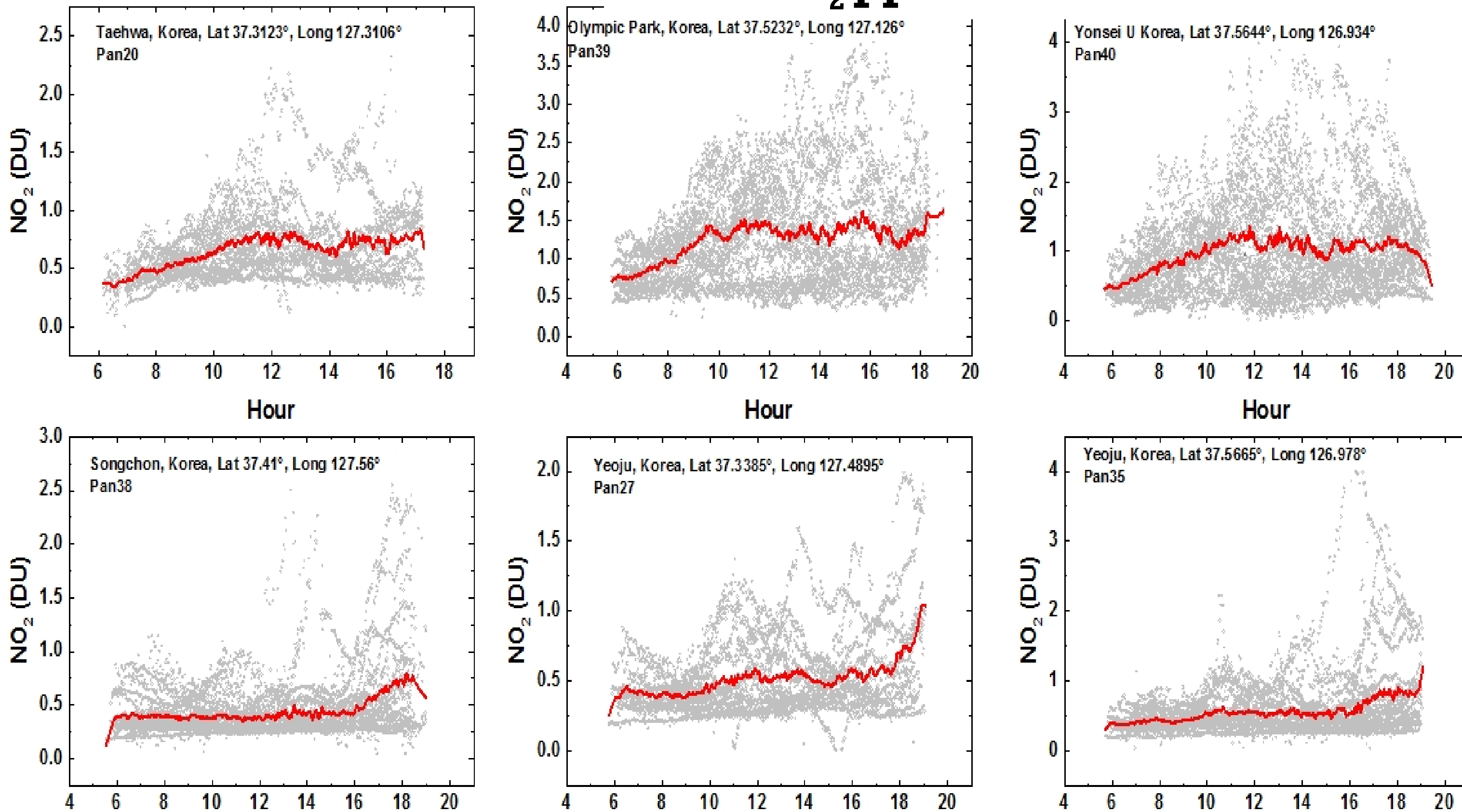
Instru.	Median (DU)	Mean (DU)	Std (DU)
Sonde	332	334	21
OMI	322	328	23
Pand.	300	305	19

Instru.	Median (DU)	Mean (DU)	Std (DU)
Sonde	318	318	18
OMI	305	310	18
Pand.	296	303	20

PANDORA SUMMARY OF 6 SITES IN KORUS-AQ. NOTE SCALE RANGES

Seoul - OLY & Yonsei – surface 20-30 NO_2 ppbv

Taehwa
Sondes-
TROPOZ
Lidar Site



Cleaner, like GSFC, 2-3 x less than Seoul

J. R. Herman

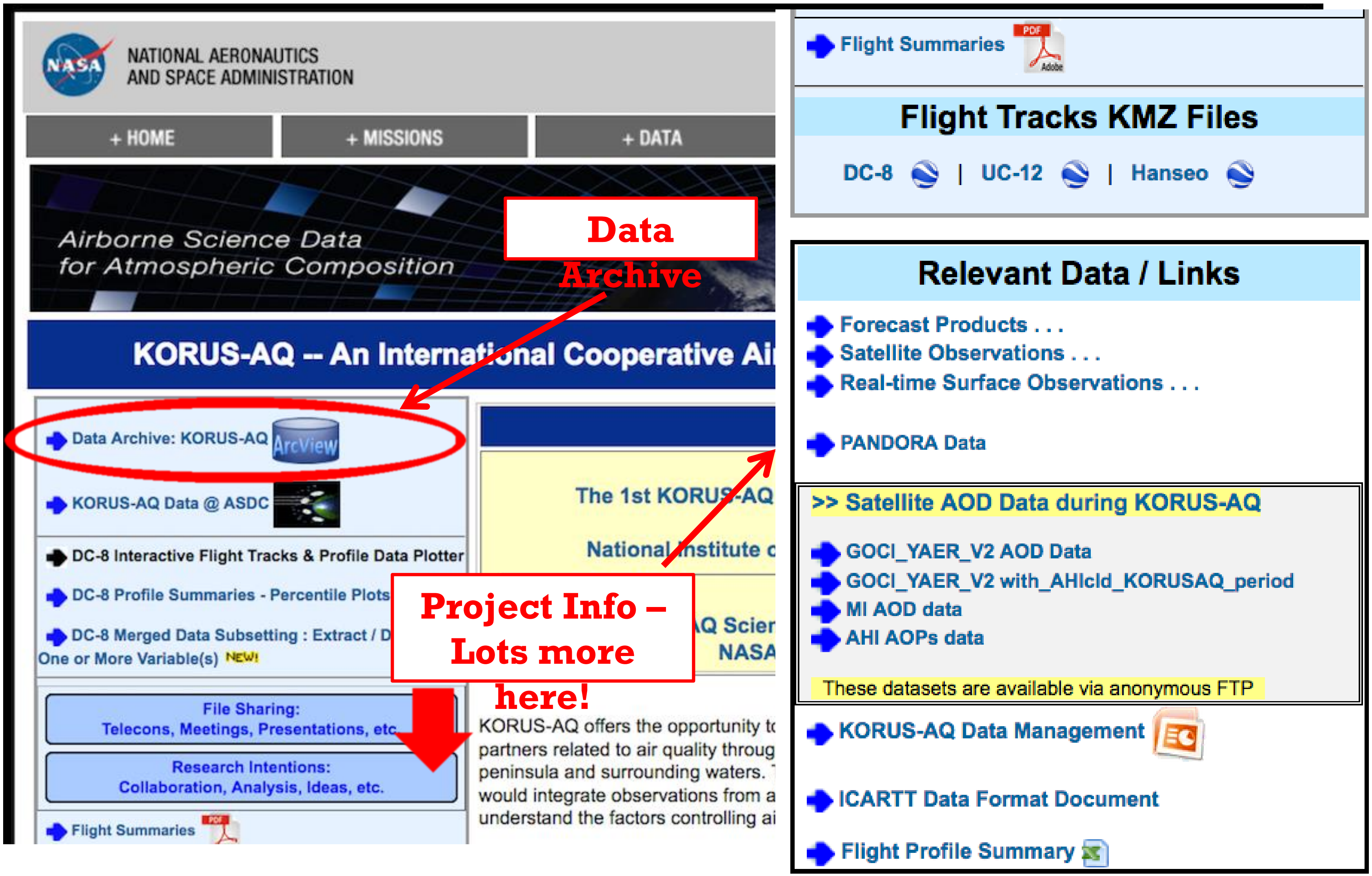
DATA ACCESS EXAMPLE:

KORUS-AQ

Archive Homepage: https://www-air.larc.nasa.gov/missions/korus-aq/

HOW TO WORK WITH FIELD DATA? USE WEB ARCHIVES. ALL DATA FROM NASA EXPERIMENTS IS OPEN!

Archive Homepage: https://www-air.larc.nasa.gov/missions/korus-aq/



DATA ACCESS EXAMPLE:

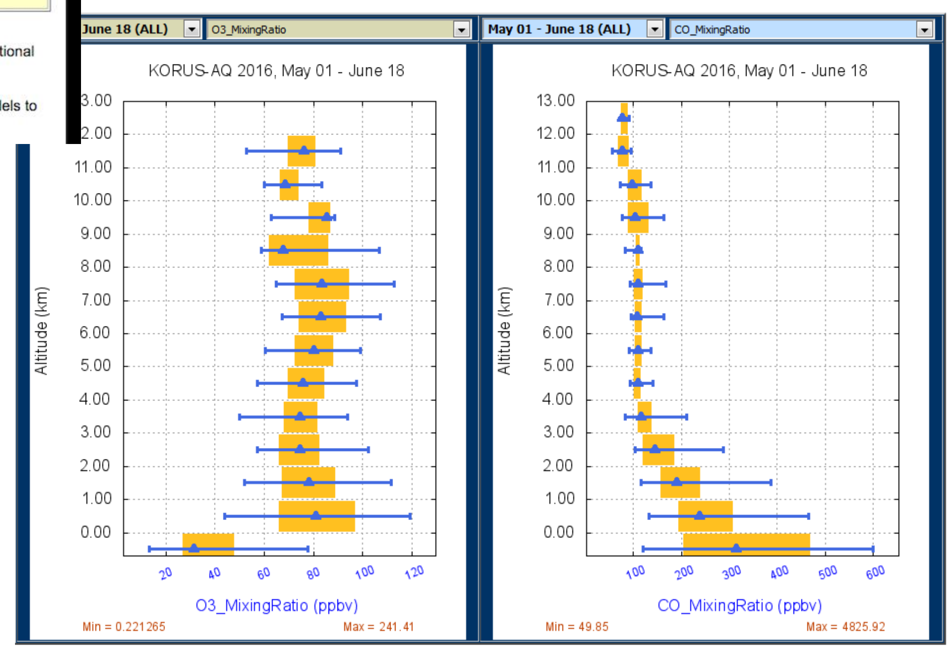
KORUS-AQ

Wealth of information on homepage including aircraft flight summaries, "quick look" plots from archived data, and links to outside sources of data and model output

Example quick look of O_3 and CO measurements from the DC-8

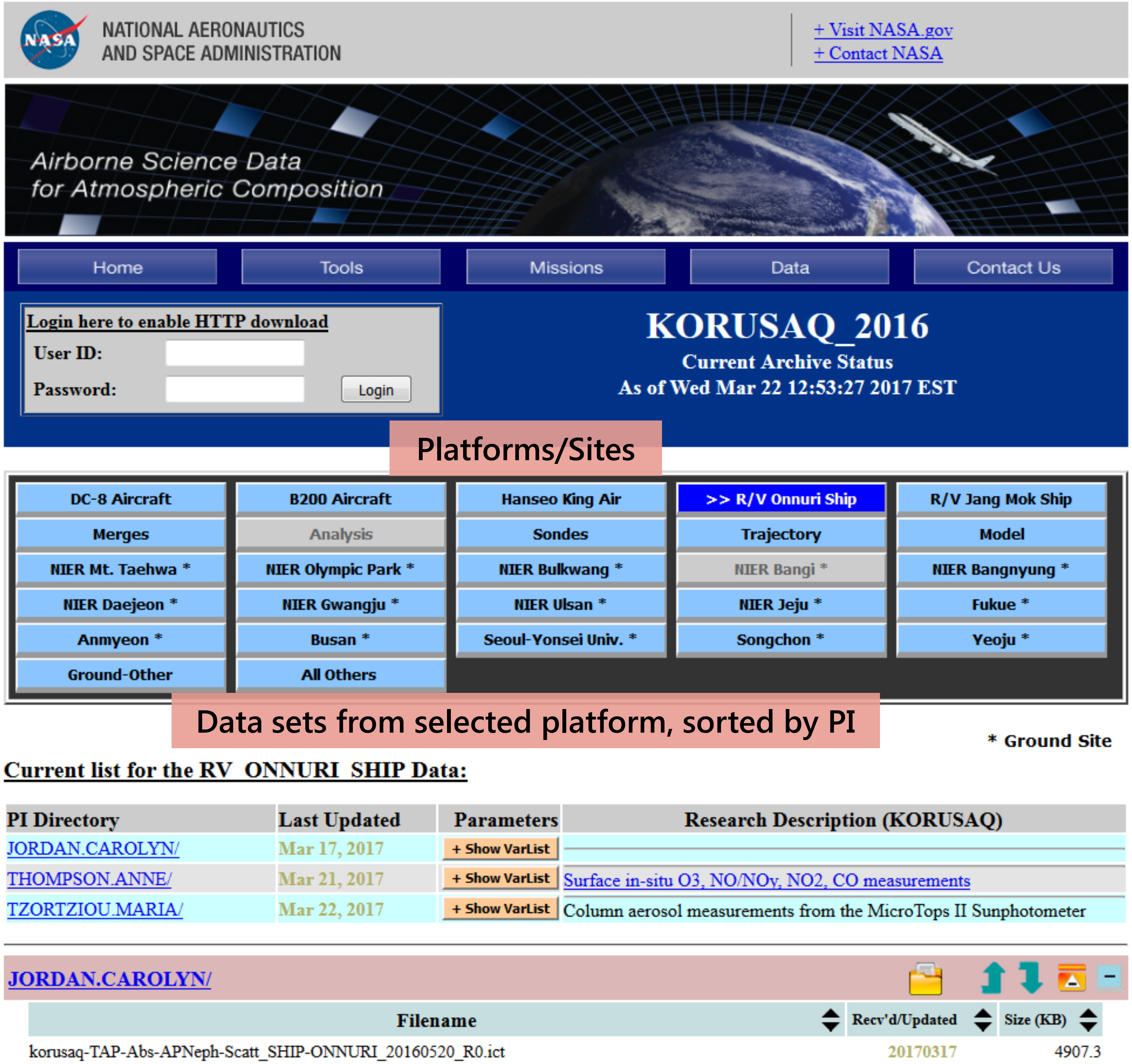
KORUS-AQ DC-8 Profile Summaries

Percentiles: May 01 - June 18, 2016 (R2)



Technical project details, White Papers, instrumentation, and participant lists are also found via this website

DATA ACCESS EXAMPLE:



Data Archive Direct Link: https://www-air.larc.nasa.gov/cgi-bin/ArcView/korusaq

Tabs to navigate to instrument platforms/ground sites and PI data sets

Standard text file formats (ICARTT)

SUMMARY: AQ MONITORING & RELATED FIELD CAMPAIGNS

- Many trace species, gases & particles, are monitored by satellite, eg. NO_2 "trends and changes"
  - Only space view tracks global change, intercontinental transport
  - Limitations in remote sensing of "nose level" pollution necessitate surface and ground-based monitoring
- Field Campaigns are assembled to answer specific questions about processes making pollution, transport & sources
  - Aircraft payloads & flights, monitoring & campaign ground sites are operated for synergistic observations
  - Models are used for flight forecasts and data integration, interpretation

LOOKING AHEAD!! ACKNOWLEDGMENTS

- **What are the BIG questions about pollution in West Africa?**
- **How does atmospheric composition over West Africa connect to changes in land-use, biosphere, water cycle & climate?**
- **PUT YOUR ANALYSES TOGETHER TO BEGIN WHITE PAPER FOR WEST AFRICAN FIELD CAMPAIGN.** ***Study meteo. Climatology, aerosol, trace gas climatology, ie seasonality & interannual variability. Use satellite and ground data***

- **Thanks: NASA, NOAA. WASCAL!!!!**

- **B. N. Duncan, L. Lamsal, A. M. Thompson et al. A space-based, high-resolution view of notable changes in urban NOx pollution around the world (2005–2014), *JGR*, 121, doi: 10.1002/ 2015JD024121, 2016.**
- **B. N. Duncan et al: "Satellite data of atmospheric pollution…" dx.doi.org/10.1016/j.atmosenv2014.05.061**
- **N. A. Krotkov et al., *Atmos. Chem. Phys.,* 16, 4605-4629, doi:10.5194/acp-16-4605-2016, 2016**
- **A. M. Thompson et al., *JGR*, 117, D23301, doi: 10.1029/2010JD016911, 2012.**
- **A. M. Thompson et al, *J. Atmos. Chem.,* DOI 10.1007/s10874-014-9283-z, 2014**
- **Y. Zhang, O. R. Cooper, A. Gaudel, S-Y. Ogino, P. Nedelec, A. M. Thompson, J. J. West, Equatorward redistribution of emissions dominates the 1980 to 2010 tropospheric ozone change, *Nature-Geoscience*, DOI: 10.1038/NGEO282, 2016.**

EXTRAS

TROPOSPHERIC OZONE COLUMN AMOUNT – DATA SOURCES

"Tropospheric ozone satellite" Products, mostly TOMS or OMI-based, are not ideal but may be usable for exploratory studies.

https://acd-ext.gsfc.nasa.gov/Data_services/cloud_slice/

Monthly maps, some software for Trends analysis

DATA: OMI/MLS tropospheric ozone (original product)
DATA: GMAO assimilated OMI/MLS tropospheric ozone profile product
MOVIES: Global tropospheric ozone movies from OMI/MLS showing the large year-round wave-one pattern in the tropics (maximum in the Atlantic), NH extra-tropical maximum around June-August (including the Mediterranean "crossroads" peak region) and SH extra-tropical maximum around September-November